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ABSTRACT

The past few decades have been an era of rapid growth and expansion for university and research libraries, yet their standards of library services have declined. Specifically, more people more often cannot get the information they seek from the library. The main factors in this decline in service are the rapidly increasing numbers both of volumes and of patrons and the changing nature of demand. Libraries still conduct their operations as if their strategy were to store and provide access to books, periodicals, papers and other materials. Their current strategy should be to supply information. This change in goals has implications for the library's acquisition, shelving and retention policies. The library's resources may be thought of as Information Message Units (IMU). The value of each IMU can be defined only in terms of its worth to its potential users, the members of the university community. A Bayesian approach can be used to calculate the information value of the IMU, thus affecting decisions on both the acquisition of volumes and the maintenance of collections. Although developed in the context of an individual library system, this approach can also be applied to networks of library systems. (Author/SL)

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Charles B. Weinberg

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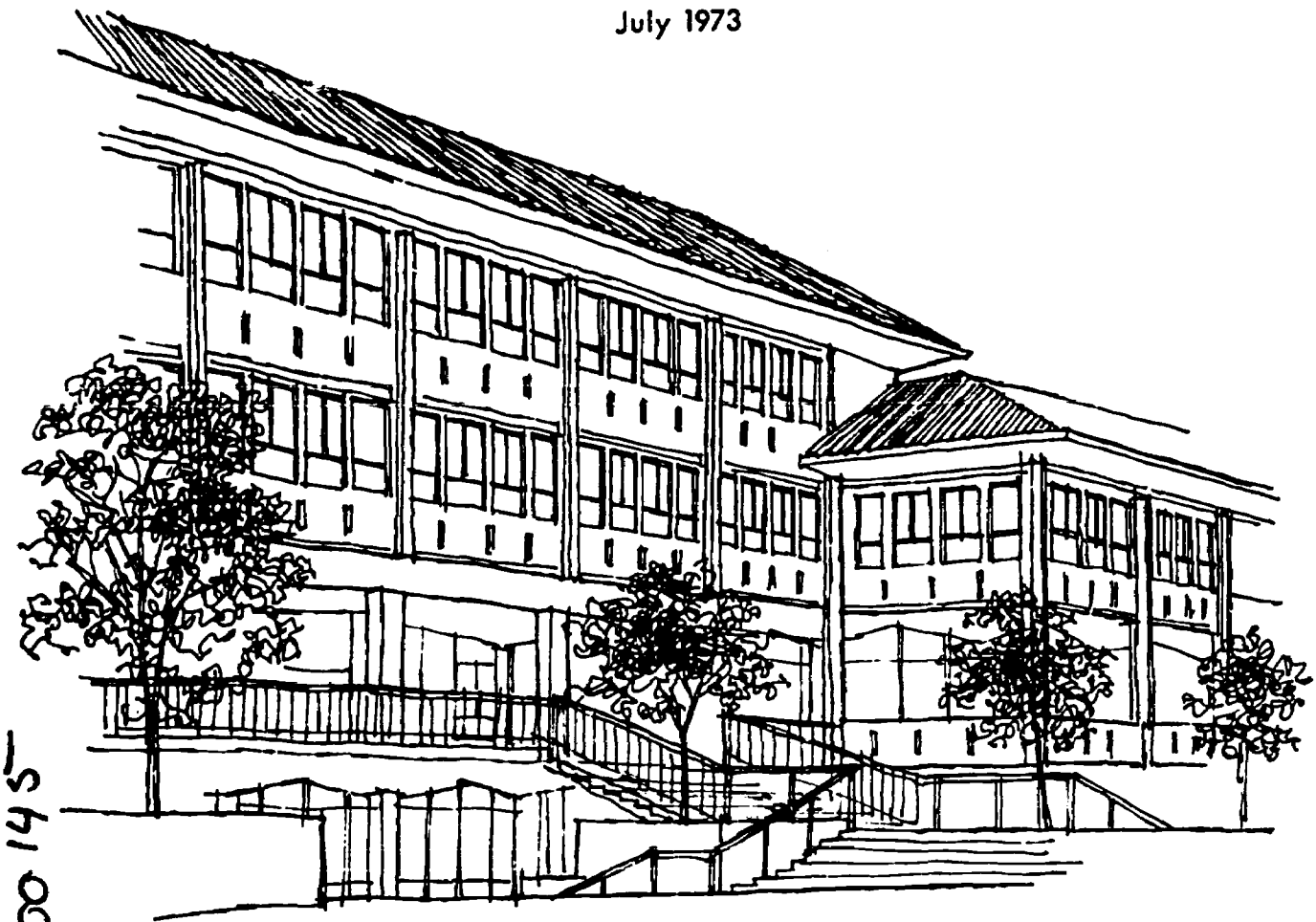

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Graduate School of Business — Stanford University

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THE UNIVERSITY LIBRARY: ANALYSIS AND PROPOSALS

Charles B. Weinberg (a)

July, 1973

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The University Library: Analysis and Proposals

ABSTRACT

The operation of the university library as a means to supply information is examined. It is shown that despite the increase in size of libraries, their standard of service is declining. Reasons for this decline are advanced. The strategic goals of the library are redefined with implications for the library's acquisition, shelving, and retention policies. A Bayesian approach is then developed for determining the information value of the library's resources. In contrast to other work in this field, stress is placed on user evaluation of the library's resources. The approach developed is applicable to decisions relating both to the acquisition of volumes and the maintenance of collections.

I

The past few decades have been an era of rapid growth and expansion for university and research libraries. For example, while it took 192 years (1754 to 1946) for Columbia University to acquire its first 2,000,000 volumes, it took only 14 years for Columbia to acquire its second 2,000,000 volumes [7, p. 10]. Unfortunately, despite this increase in resources, library service has declined because of the increased and changing nature of demand. Specifically, more people more often cannot get the information they seek from the library.

Three main factors are the cause of this decline in service. The first is that the increase in number of books, journals, periodicals, government publications. working papers, conferences, speeches, and other sources of information (henceforth referred to collectively as volumes) and the increase in number of users have overwhelmed the increase in library resources.

As shown in Table 1, the doubling rate of books published and of potential users has increased at a greater rate than that for volumes in the university library. Thus a library has a decreasing fraction of total volumes published and has to serve a growing population.

A second factor in the declining library service is the increasing specialization of fields. Kemeny [5, p.90] dramatically describes the situation:

> Specialization is the order of the day. To make a contribution to a field, the researcher must have reached the frontiers of knowledge. It is very hard to do this, unless one is willing to focus one's attention on a narrow segment of the field. Non-mathematicians have long ago given up trying to understand current mathematical research. It is becoming increasingly difficult to attempt communication between mathematicians.

Thus, as researchers develop narrower and narrower ranges of interests, the number of works that can be shared with other researchers declines. In order to provide the same amount of information per user, a greater number of volumes per user is required.

A third factor is a result of the "discipline-mission duality" [13]. Traditional disciplines such as physics, biology, and mathematics are being complemented by interdisciplinary fields such as operations research and American civilization and mission oriented fields such as space research. It is no longer easy to identify a volume with a particular user. Thus, a researcher may have to search in many libraries before finding the volume he seeks. As specialized collections become located in different physical locations, the cost to the researcher becomes higher in terms of time lost. One solution is to buy copies of the volume for each of the specialized collections. This, however, sacrifices funds which could be spent to keep up with the increase in literature. Another problem that the interdisciplinary studies introduces is in the selection of volumes to be purchased. For example, how should a book in sociology which may have use in American civilization studies, business schools, comparative religions, and sociology be evaluated? Thus, the discipline-mission duality increases the difficulty of volume selection and location.

In summary, both the increase in amount of demand and the change in type of demand have led to declining service from libraries. An approach to reversing this trend is developed in the following sections of this paper.

II

In order to analyze the library and develop a framework of methodology for improving library services, we must define the proper strategy for libraries. By strategy we mean [2, p.16] "the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals." The concept of strategy is vital to an organization; it provides a means of channelling resources in an orderly structured manner to achieve objectives.[1]

Libraries currently conduct their operations as if their strategy were to store and provide access to books, periodicals, papers, and other materials. The reason for this strategy is most likely historical. Libraries were originally book collections and while they now contain other materials, no major effort seems to have been made to reevaluate this strategy. Their current strategy should be to supply information. This new strategy is not merely a change of words. We will demonstrate the significance of the difference between the two strategies.

The first difference is "...to store and provide access to..." versus "...supply..." A library places heavy emphasis on its storing function to the detriment of its ability to provide access. The policies followed for the binding together of a year's journals demonstrate this phenomenon. At the end of the year, the library gathers together all of the year's issues and sends them to the bindery. This is done to prevent the loss of single issues which are often difficult to replace and to protect and preserve the individual issues. The binding process usually takes at least three months. However, it is during the period just after its issue that a journal is most in demand. Thus journals are taken out of circulation in their most demanded period to allow for use when they will not be heavily demanded.[2]

The second difference is "...to provide access to books, periodicals ..." versus "to supply information." Libraries place heavy emphasis on the physical characteristics of objects. Separate housings are often maintained for microfilms, current and bound periodicals, and other items. They are not stored with other physical objects which bear on the same topic. Further, comparatively little attention is paid to non-printed materials. Finally, the criteria for the listing of items in card catalogs are based on physical characteristics. For example, books are listed in card catalogs but articles are not. Certainly, there are many articles which should be listed individually because of their significance, but many books which could be removed from the card catalog or demoted to a Reader's Guide type of listing. As another example, if emphasis were placed on supplying information, then we might expect libraries to duplicate (with copyright permission) sections of books that are useful or in much demand. Under this system, the best way to meet the demand for a book such as William Feller's Probability Theory and Its Applications might be to divide it into chapters since the demand is often for particular sections rather than the entire book. In marketing terms, we must design the product to fit the needs of the customer.

For the remainder of this paper we will consider a library as an enterprise designed to supply information. For emphasis, we shall call the commodities that a library deals in to carry out its strategy by the name Information Message Units, abbreviated I.M.U.

III

In order to define more fully the objectives of a library, we must introduce two concepts: (1) the value of information maintained and provided, and (2) the cost of service to provide this information.

The value of information can only be defined in terms of its worth to its potential users, the members of the university community. Thus, there cannot be an objective measure of an item's value--the measure must be subjective. Furthermore, because a library maintains items in

anticipation of their future usefulness, the value must be probabilistic. Let us discuss this more fully. A library purchases and retains I.M.U.'s which it feels have sufficient potential usefulness for the university community. Once a particular individual uses an I.M.U., he can then make a better estimate of its value to himself or to others. His evaluation (see discussion of measurement below) will apply to future use of this I.M.U. for the same purpose as his or for other related purposes. In Bayesian terms, he is updating prior probabilities to obtain posterior probabilities. In other words, the following system is developed:

Prior

P_i...probability that user group i will use the item (note, the sum of the P_i's is $\gtrless 1$)

$R_{j|i}$..probability that the information obtained will have value j if used by user group i

$E_i = \int jR_{j|i}$...expected value of this information to user group i if it uses it at all

$C = \int P_i E_i$...expected worth to entire community

Posterior

Upon a user's experience, the values of P_i and $R_{j|i}$ can be updated to obtain

$E_i' = \int jR'_{j|i}$

$C' = \int P_i' E_i'$

This system's usefulness depends upon the ability to measure and update the parameters P, R, and j. In the following paragraphs we will attempt to show that this determination is currently being done on an individual by individual basis. What is needed is a standard scale for j. It is suggested that such a scale is obtainable.

The approach suggested here is in contrast to that in [8] and [12], where the emphasis is on utilizing circulation data alone to decide stocking and storage questions. Circulation based approaches necessarily do not deal with the original purchase decision and put infrequently used but high value volumes at a disadvantage. On the other hand, these approaches eliminate the need for a user evaluation system. The approach developed here, however, can lead to integration of the purchase and retention decisions on the basis of a value versus cost comparison.

To the members of a university community, time is an important constraint. Because of the exponential increase in the quantity of literature produced, a person no longer has time to read all that is written in his own and associated fields. Thus, the decision on what to read is not made lightly, it is of serious concern to the individual and is usually well thought out, at least implicitly. Thus, a person does not read at random, but reads what appears to be most useful to him. In other words, he calculates the expected value of books, journals, etc. to him and then chooses what he will read. This expected value is based on reading book titles, previous experience with an author, recommendations, and other factors. The purposes may differ for reviewing different items. Some are read to remain current in one's own speciality and to know what one's colleagues are doing, others are read to maintain a general knowledge of the field, others to provide material for lectures, and so on. The important points are these: One, prior to reading the item, a conscious decision is made as to the expected value of an item. In other words, a person is calculating his E_i. He may calculate the E_i directly or by thinking in terms of $R_{j|i}$ and j. Two, after reading an item, he can make a new estimate of E_i. In addition, the specialist library staff who are trained in both academic fields and librarianship can be of aid in operating this evaluation scheme. Such staff could assist in discovering potential sources of I.M.U.'s as well as in setting the E_i's.

The problem now is that people might not be able to think of E_i or j in quantitative terms, and that if they do, they will all be using different scales. Let us attack the second case first. One can infer from [13], that all branches of science have followed rather closely the same growth pattern, especially with respect to the development of the literature (see p.10 especially). Now it would seem likely that the probability distribution of the quality of literature would be the same in any field. As a hypothetical example, we might see the following distribution:

Probability	Value
5%	Very High
10	High
30	Medium
40	Low
15	None

After developing the shape of this distribution, we could then promulgate it as the scale to use in assigning values. That is, when reviewing current literature, evaluate it in terms of a long run frequency distribution. Short run deviations would, of course, be expected. If the probability distribution would be accepted, then the range each individual uses--once specified--could be adjusted later for overall conformity. Again, if we consider those people who do not think quantitatively, we must at least be able to convince them of the validity of the probability distribution for quality discussed above. If they can then develop qualitative evaluations that fit key points on the curve, it would then be possible to interpolate for the quantitative values to a sufficient degree of accuracy.

The user evaluation system may possibly operate in the following manner. On a periodic basis, users are given a list of I.M.U.'s the library is considering acquiring. Alongside each item is, for example, a five point scale on which the user checks his evaluation or gives his

probability of the I.M.U. being in that category. In order to conserve user time, a specialist librarian can edit the list so that all I.M.U.'s which have a high probability of being at the extremes may be omitted or placed in a separate category in which the librarian's evaluation is given. Thus, the user needs to evaluate only those I.M.U.'s which the librarian thinks are likely to have an E_i in the middle of the range.

It thus seems reasonable that the expected value of information to an individual or to a group of individuals in the same field can be obtained. In other words, we can derive the parameter E_i. In order to evaluate a volume, however, we need to aggregate over all the different groups in the university. Furthermore, as we discussed earlier, the value of E_i changes as a result of experience. That is, it must be updated. In section V we will describe a procedure to carry out this aggregating and updating of the information value. For the present, let us assume that a current value of C can be obtained. The objective of a library can now be defined operationally as "to maximize the amount of information supplied to its users."

This maximization is subject to at least two constraints. The first is a service criterion that includes the time a user must wait before a request is fulfilled and the percentage of time that a request cannot be filled. It is essential to realize that a library cannot meet every request, and for those that it can meet, it cannot always supply the necessary I.M.U. immediately.[3] The concepts of inventory management as related to the flow of information are valid here. Probabilistic assessments of stock outs, lost sales, and order cycle times must be made. In business inventory management, an attempt is made to convert these assessments into dollar figures so that operating policies can be set which maximize profits. For libraries, no method of converting information values and service standards into a single measure appears to be at hand. A framework for setting service standards, however, can be developed.

We have already developed a measure of value for I.M.U.'s. It would seem that the greater the value of information, the more stringent the service standard we would set.[4] Thus we could divide all I.M.U.'s into some arbitrary number of ranks, and for each rank set a standard for service.[5] A summary control system report might appear as follows:

Rank	Value of Information Provided	Average Time to Provide Information	Value of Information Not Provided
1			
2			
.			
.			
.			

As experience is gained with the system, reasonable objectives for "Average Time to Provide Information" and "Value of Information Not Provided" can be developed.

A second constraint is financial. The library must work within a budgetary limitation. However, the present method of allocating funds to book buying, buildings, salaries and capital equipment and facilities is improper because it is arbitrary with respect to the objective of supplying information. In the next section, we will show how the application of this strategy requires a library to rethink its policies on the storage and retention of I.M.U.'s.

IV

A library is an enterprise which attempts to maximize the amount of information it supplies within financial and service constraints. To achieve this objective, it carries out five main operations--the procurement, processing, storage, dissemination, and disposal of I.M.U.'s. The first four are standard functions of a library, the last is not often thought of as being a means to achieve a library's objectives. The

costs of these operations are substantial; for example, for serial publications the average initial cost of acquiring and cataloguing a new title, was found to be $60.60 in a survey of four university libraries. [12]. Storage costs consist of annual recurring costs of actually caring for the items held in storage and a fixed one-time charge for building and equipping the storage facilities. The service standards that are set have a large effect on storage costs for two reasons. First, lower priority items can be stored more compactly so that less storage space is required per item. Second, the storage location for lower priority items can be moved to less valuable land than that on which the main library is located. From an economic standpoint, this cost is significant.

The fifth operation--disposal of I.M.U.'s--at first seems contradictory to how a library should function. However, it is not. The principle behind this operation is that the funds freed by disposing of I.M.U.'s can be used to purchase other I.M.U.'s which have a higher expected information value. This principle is operational because of the rapid decline in frequency of usage of most I.M.U.'s ten to fifteen years after their publication, as Table 2 illustrates for the books in the Yale Medical Library. Although the number of books published in 1960 (15,012) is 2.3 times the number published in 1945 (6548), the Yale data show (157/12=) 13 times as many uses of 1960 books versus 1945 books. (This topic is pursued in depth in [12].) Our conclusion is not that all old books should be thrown out, but that many of them should be stored in a more remote location or in a regional or national archive. This decision depends upon the expected value of the books as opposed to the costs to be saved and possibly the salvage value of the old books. Since the decision is based on the expected value of the I.M.U., old but high value I.M.U.'s will be retained. In other words, we can derive a number representing Expected Value per Dollar. (Note that by placing an item in a lower storage category, we increase the Expected Value per Dollar. Thus, most books would go through a series of storage locations before being disposed.) The other side of the decision is whether to buy a new book. The relevant costs here are procurement, processing, and storage costs. Thus, for new books, we can also

calculate an Expected Value per Dollar. The library then allocates its funds between storage of old volumes and purchase of new volumes so as to maximize the expected value of its collection.

One argument against the disposal of old works is that possibly invaluable but as yet unrecognized discoveries are contained within them. There are two counter-arguments. The first is that the discovery will be made later by someone else and that the information will not be lost to mankind for ever. For example, although Gregor Mendel made his famous studies of garden peas to develop the theory of dominant and recessive genes in 1865, it was not until 35 years later "that his paper was 'discovered' by three biologists. All three were working independently on the same kind of problem that Mendel had investigated. These men... obtained results that agreed with those of Mendel." [1, p.527] Thus, we may surmise that even if Mendel's work had never been found, the same principles would have been discovered. The second counter-argument is that the amount of time saved in research by eliminating all the inconsequential works from reading lists by making them no longer available more than offsets the time lost because a particular discovery was not known.

Finally, the system need not go so far as to destroy all copies of a volume. We can envisage a series of interrelated libraries on a hierarchial basis. When there is insufficient demand at a single library to buy or retain an I.M.U., the I.M.U. can be evaluated at the next level of the system. Because the higher level will cover a larger population, the value of the I.M.U. will be increased relative to its value at the more local level. Further, presumably the higher the level the lower the storage and holding costs. The ultimate level, which would have the lowest storage cost, would then buy or retain all I.M.U.'s which were not elsewhere in the system. Because only I.M.U.'s which fail to meet the standards at one level go on to the next higher level,

the final library will not be a collection of all I.M.U.'s , but rather of those which were not sufficiently valued to be retained at more accessible levels.

V

In this section, a procedure will be described for libraries to select and maintain volumes in their inventory of information in accordance with the expected values of the potential users. This procedure is best illustrated by a flow chart (see Table 3) and the following remarks are designed to clarify understanding of this flow chart.

Boxes A and B: New titles for possible acquisition are brought to the attention of the library either through conventional channels or by faculty recommendation.

Boxes C and D: In the first section of this paper, we described the discipline-mission duality. Volumes no longer are of interest to a single group in a university community but instead work in different subject areas may be of concern to many. Steps C and D deal with this duality. In step C, volumes are classified into their subject "category". In step D, the faculty is classified into "groups". The categories and groups may or may not be identical. The important point is that each faculty group indicates in which categories of volumes they are interested. For example, the international affairs group may be interested in volumes on economics, political science, and history. Steps C and D operate as follows: after a volume title and description comes to the attention of the library, it is classified as to category and then sent to the interested groups for evaluation.

Boxes E, F, G, and H: As indicated earlier, each group (with the help of specialist library staff if available) rates a volume as to its expected value for that group (E and H). As discussed previously, the

specialist librarian may edit the list presented to the user so that only the "borderline" evaluations need to be obtained from the user. This rating must then be combined with others in order to determine its overall expected value to the community. In some cases, a book may be of interest to a particular group even if not other groups wish to utilize this volume. In such a case, steps F and G provide a means for purchasing this volume. (By placing limits on the quantity that each group can order for its own interests, a control can be placed on the use of Box F. If a group has an excess of volumes which it wishes to purchase via Box F, it can superimpose this entire system for its own subgroups).

Boxes I and J: In a previous section, we indicated that an E_i value could be obtained. The development of the measure P_i was postponed. P_i was described as the probability that the i^{th} group would read a particular volume. This probability cannot be easily obtained for each volume. However, a reasonable substitute is each group's probability of utilizing an item from a particular category.[6] These probabilities weight each group's expected value to yield an expected value of the volume for the community. Furthermore, these weights can be modified so that groups which the university wishes to emphasize can have a more significant influence in the valuation of volumes. (This is also done directly by the controls set on step F.) In summary the category assignment of a volume determines which groups will review it and the influence of their judgments.

Box K: The expected value of a volume is compared to other possible uses of library funds and if the value is sufficiently high, the volume is purchased. A volume which originally is not purchased may later be acquired because of changes in other opportunities.

Box L: Upon receipt, the volume is assigned to its proper storage location.

Box M: An important function of the library system is to maintain the expected value of its possessions on a current basis. This is especially important in view of the arguments made earlier on the question of disposing of volumes and altering their storage location.

Two processes operate to carry this out. The first is automatic and depends upon the age of the volume. In accordance with data similar to that used in Table 2, a deterioration factor is applied to the expected value of volumes as they grow older. The second process depends upon usage. Each time a person uses a volume, he would be required to submit a new estimate of its expected value; in other words, the prior probabilities are revised on the basis of sample information. The structure of the system is designed so that it is to his advantage to reevaluate the volume whether he found it useful or not. If he found it useful and does not indicate that this is so, then the automatic deterioration process will lower the volume's expected value and he may not be able to obtain it again. If the user did not find the book informative, then failure to downgrade it allows it to deteriorate less rapidly than it should and thus prevents its replacement by new materials.

This completes the description of library selection and maintenance procedure. This procedure can be extended to journal articles in a way to determine whether or not an article should be listed in the card catalog. As long as an article maintains a high enough expected value of information it can be maintained in the card catalog listing.

Through this procedure, a library can maintain its collection so that it functions to maximize the information it supplies to the entire university community.

VI

This paper has confined itself to the design and operation of a university library system viewed primarily as an entity in itself.

However most university libraries have developed interrelationships with other universities in order to share the burden of keeping up with the vast growth of I.M.U.'s. These relationships are of two types. In one type, libraries form agreements among themselves in which each library agrees to specialize its collections in some areas and essentially serve as a resource library to other libraries in the agreement. In terms of the framework developed in this paper, the library is expanding the number of user groups i that it includes in its calculation for an I.M.U. decision in the areas in which the library will specialize. Operationally, rather than attempt to develop ratings from a geographically dispersed set of users, the system could be designed so that probabilities of usage in certain groups be modified as suggested in the description of Boxes I and J.

In the type of network agreement described in the previous paragraph, decisions about I.M.U. availability are made prior to specific user requests. (In such cases, it would be logical to list I.M.U.'s in card catalogues of all the libraries in the specialization agreement.) The other type of network arrangement applies to instances when a user requests an I.M.U. which the library does not have. Through the use of the Union catalog and interlibrary loan agreements, the library can find out where the I.M.U. is located and borrow it for the user. Thus, one effect of the network system is to transform a library's decision not to acquire or to continue to maintain an I.M.U. from one of non-availability to the researcher to one involving the time to gain access to an I.M.U. However, currently, the time to acquire an I.M.U. on an interlibrary loan is considerably longer than the time required if the I.M.U. is presently in the user's own library system.[7]

The approach described in this paper for an individual university library system can be applied to networks of library systems. For example, we may view each university library as a user of a regional

system, and each regional system as a user of a still larger system, and so on. Then according to the value and probability of use of I.M.U.'s in particular communities, the locations of I.M.U.'s could be set. By balancing costs and potential usage, sizes of different libraries in an overall system could be developed. As in an individual library, the key point is the accurate assessment of a library system's strategy and objectives and the development of effective actions to reach these goals.

TABLE 1

DOUBLING TIMES FOR VOLUMES AND USERS*

	Time to Double	Annual Growth Rate (Assuming Exponential)
Number of Volumes Produced [14]	10-15 years	6%
Number of Volumes in Columbia Libraries [7]	21-24 years	3%
Number of Scientists [14]	10-15 years	6%
Number of University Students in U.S. (3)	15-20 years	4%
Number of University Faculty in U.S. (3)	15-20 years	4%

*Data inferred from the references listed.

TABLE 2

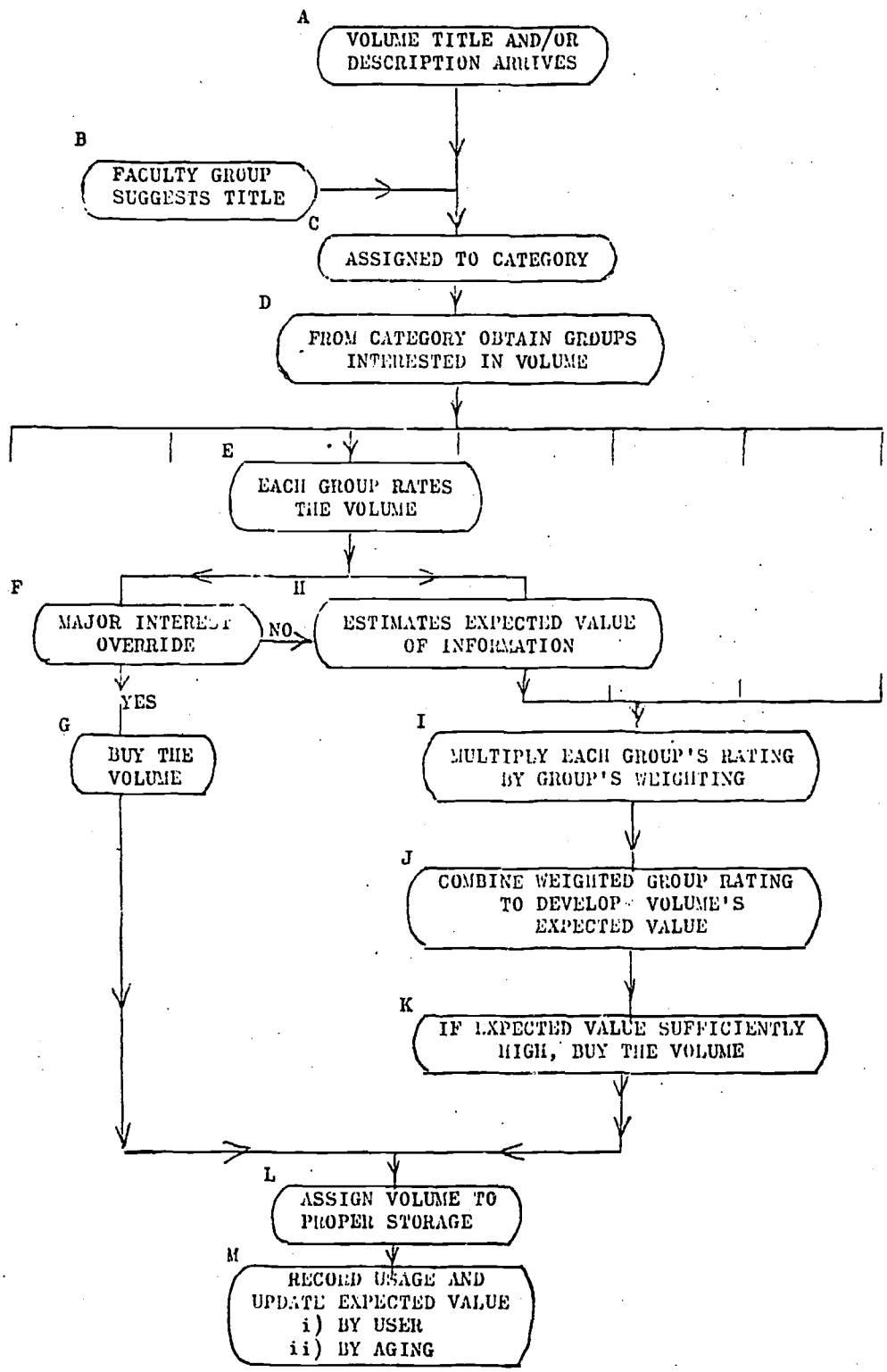
RECORDED USE OF BOOKS IN THE YALE MEDICAL LIBRARY BY AGE OF BOOK*

Age of Book (Years)	1	2	3	4	5	10	15	20	25	30
Uses of Books	157	121	118	86	90	54	12	4	10	3

*Derived from data in [6]

TABLE 3

PROCEDURAL FLOW CHART



FOOTNOTES

1. The following analysis is based on the author's experience in several large libraries in American universities.

2. In fact, some libraries do recognize this problem and practice delayed binding in which, for example, 1971 journals are not bound until the end of 1972.

3. See [10] for a methodology for testing delivery time in a library and an analysis of results. See [4] for a description of a market research procedure to determine customer reactions to different service policies.

4. One device to prevent people from placing high values on all items would be to have longer borrowing period for lower valued items.

5. A lower standard of service can result in a library saving money by assigning a lower level of personal resources, employing a less expensive bibliographic format, and storing the I.M.U. in a less expensive storage area.

6. The circulation system can be designed to provide these usage probabilities. For example, the computerized circulation system at Ohio State University provides this information as a by product of its circulation control function [9].

7. Data on time from when a user requests a volume to the time at which the user receives it are not generally kept by libraries. However, Orr and Schless [11] report, in a study of biomedical libraries, that in a test, the median time period from library initiation of a request to its receipt was 8.7 days.

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